

Forum

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cutting-edge technology and scientific expertise and excellence to make the case for science funding to maintain our nation's status as a world leader in the geosciences. Our foreign competition is catching up and in some cases has already surpassed us, weather forecasting models in Europe being a good example. Consider China, Brazil, and India, all of which are significantly increasing their investment in at-sea, atmospheric, Earth, and land-based laboratory infrastructure and human capital. China is building two 7000-meter human-occupied submersibles, and all three countries are constructing several large research vessels.

Given the immense fiscal, political, and scientific challenges facing the geosciences, we have to learn how to work together better as an Earth systems science community rather than a group of individual independent organizations. We also need to exercise "appetite control" by demonstrating an ability to set realistic priorities through decadal planning exercises. Our current model of doing business has to change because the budget constraints we are facing will not go away any time soon. Thus, the situation we are in is a dramatic sea change from budget scenarios of the past, and it is highly unlikely that we will go back to the way things were during the Cold War, when anti-submarine warfare

and the need for new innovative weapons systems such as advanced satellite technology drove the nation's research agenda. Our ability to conduct science in such an environment requires a paradigm shift in how we operate.

Finding the Best Opportunities

Despite the extraordinarily challenging funding situations we face as scientists, I am an optimist. I believe that if you have a glass-half-full attitude in life rather than a glass-half-empty view, you will not spend your life thirsty. I also suggest to you that in chaotic and depressing times, there is opportunity if we are willing to change. While others are wringing their hands, those who accept and embrace change move forward and succeed. The decision is ours, and we need to make it now.

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Economic Growth in the Face of Weather and Climate Extremes: A Call for Better Data

The U.S. economy has grown to be the world's largest, even in the face of the most varied and costly weather and climate extremes on the planet (see http://www.munichreamerica.com/webinars/2013_01_natcatreview/MunichRe_III_NatCat01032013.pdf). Nevertheless, these extremes continue to take a toll on the nation, diverting public and private funds while limiting economic growth and jobs and threatening the well-being of Americans. Extreme weather events affect every state and manifest differently by region (see Figure 1 in Supporting Information in the online version of this Forum and <http://www.ncdc.noaa.gov/billions/summary-stats>).

The United States is not alone in its vulnerability to weather and climate extremes. A recent Intergovernmental Panel on Climate Change (IPCC) assessment found that the impacts of extreme weather, climate, and geophysical events have increased globally [IPCC, 2012].

While adaptation, preparedness, and improved forecasting have helped reduce impacts, weather and climate extremes are increasingly frequent (see Figure 2 in Supporting Information in the online version of this Forum and Karl and Katz [2012]) and apparently more costly [Karl et al., 2009; U.S. Climate Change Science Program, 2008]. The National Climatic Data Center (NCDC) reported a record number of billion-dollar weather and climate disasters in 2011, at 14, with 2012 close behind, at 11 (see <http://www.ncdc.noaa.gov/billions/events>, <http://www.ncdc.noaa.gov/extremes>, and <http://www.ncdc.noaa.gov/sotc/national/2012/13>).

Even as scientific understanding of the economic consequences of these extreme events improves, the nation lacks the data necessary to comprehensively understand their economic costs across years, events, and places. We are limited in our ability to accurately assess the changes in magnitude and composition of event costs, to more skillfully attribute the causes of changes in the costs of weather and climate extremes, and to state with confidence when and how policies intended to limit these impacts are working.

Our ability to attribute the causes of the increasing costs of weather and climate

extremes and the success of policy is diminished by the fact that long-term data on economic damages from extreme weather and climate events are neither complete nor consistent across federal agencies and the private sector [Smith and Katz, 2013]. No central federal authority consistently collects all relevant data and tracks the economic impacts. The private sector collects data on insured losses that result from weather and climate extremes but has not created a public domain data set and analysis framework that is sufficient for understanding the broader economic impacts. It has, however, collaborated closely with federal entities to provide data for special uses.

By comparison, the weather and climate community has a long history with a global monitoring network that is used to detect changes in weather and climate extremes, but by no means is it adequate [Trenberth et al., 2011]. For example, there are no data sets (with confidence intervals) for tracking changes in critical extreme events such as severe local weather (e.g., tornadoes, hail, and damaging winds). For other phenomena (e.g., hurricane intensity), error estimates for some regions are often wide and uncertain [Karl et al., 2009; IPCC, 2007]. Well-calibrated, unbiased data are required to explain the causes and costs of changes in these events; better observations lead to more confidence [Vose et al., 2013; Peterson et al., 2013]. The outlook for consistent observations for a variety of extremes is still challenging for both in situ [Global Climate Observing System (GCOS), 2003] and satellite observing systems [GCOS, 2010; National Research Council, 2008].

Current Systems for Collecting Data

The private sector collects data on certain economic impacts associated with U.S. weather events and hazards. Insured loss estimates are compiled by Property Claim Services (PCS). Uninsured losses are estimated by various means, often roughly expressed as a multiple of direct insurance losses. The PCS data include only those

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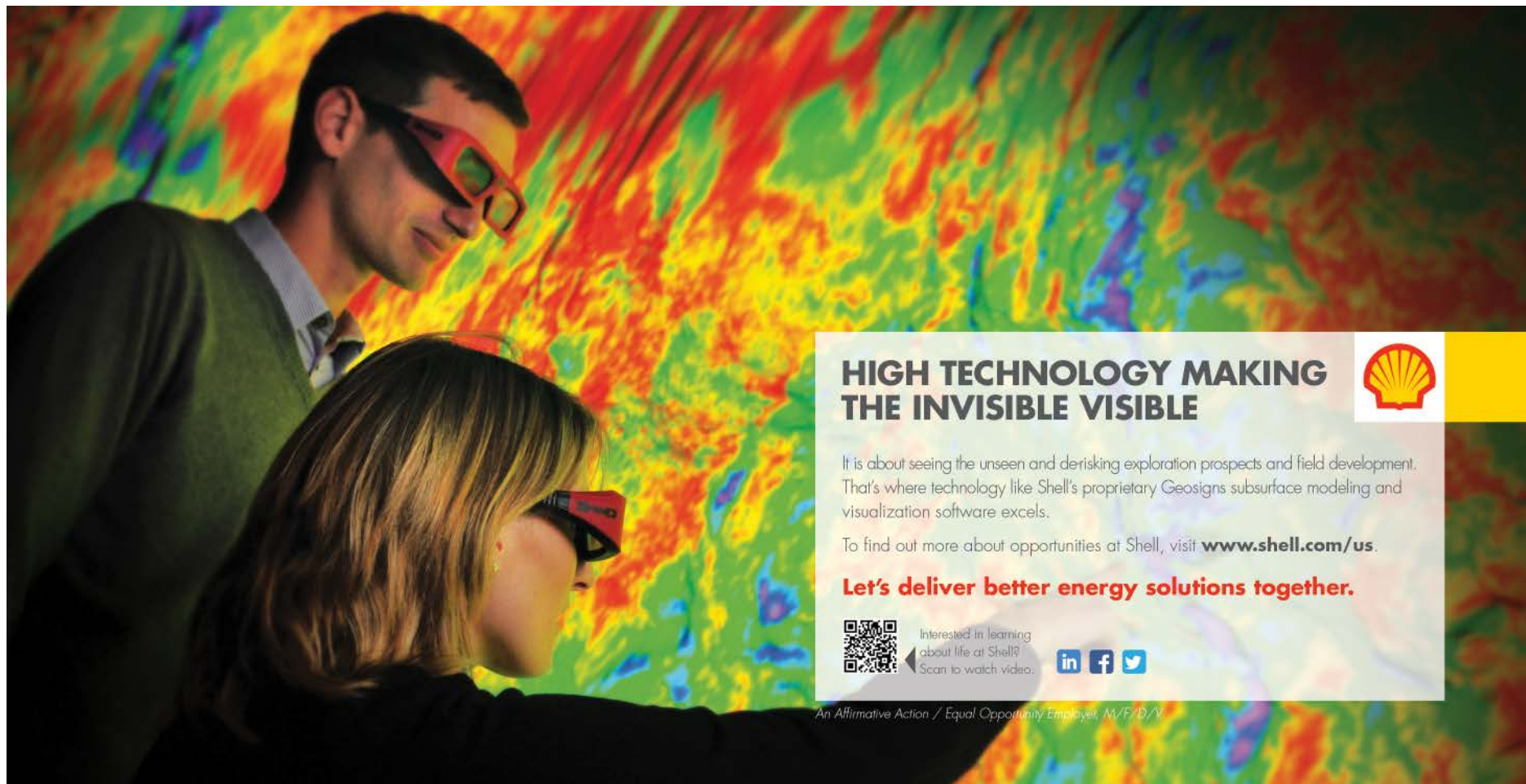
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Federal data collection is uniformly bottom-up; agencies compile data from disparate local sources. USDA collects data from county-level agriculture agents. NWS compiles data on weather impacts from forecasters at the nation's 122 weather forecasting offices. Across all of these institutions, there is no consistent methodology

The National Research Council recently released a report on natural disaster socioeconomic impacts, including weather and climate extremes, and recommends risk-based approaches to resiliency that require improved data, modeling, and response for natural disaster anticipation [*National Research Council*, 2012].

The federal government plays a pivotal role as risk manager and insurer of last

Because weather and natural disasters are ubiquitous, often with cross-border effects, a similar effort should be considered at a global level (see <http://www.irdrinternational.org/about-irdr/scientific-committee/working-group/disaster-loss-data/>). Without accurate and reliable data on the impacts of these events, our ability to manage and grow the economy will only worsen, in turn, compounding climate risk and placing more costs on government.

We acknowledge the contributions of Adam Smith, Neal Lott, and James McMahon of NOAA's NCDC and the participants of NCDC's May 2012 Workshop on Billion Dollar Weather Damages.

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Growing the U.S. Economy in the Face of Weather and Climate Extremes: A Call for Better Data – Supplementary Material

Linwood Pendleton¹, Thomas R. Karl², and Evan Mills^{3,4}

Figures

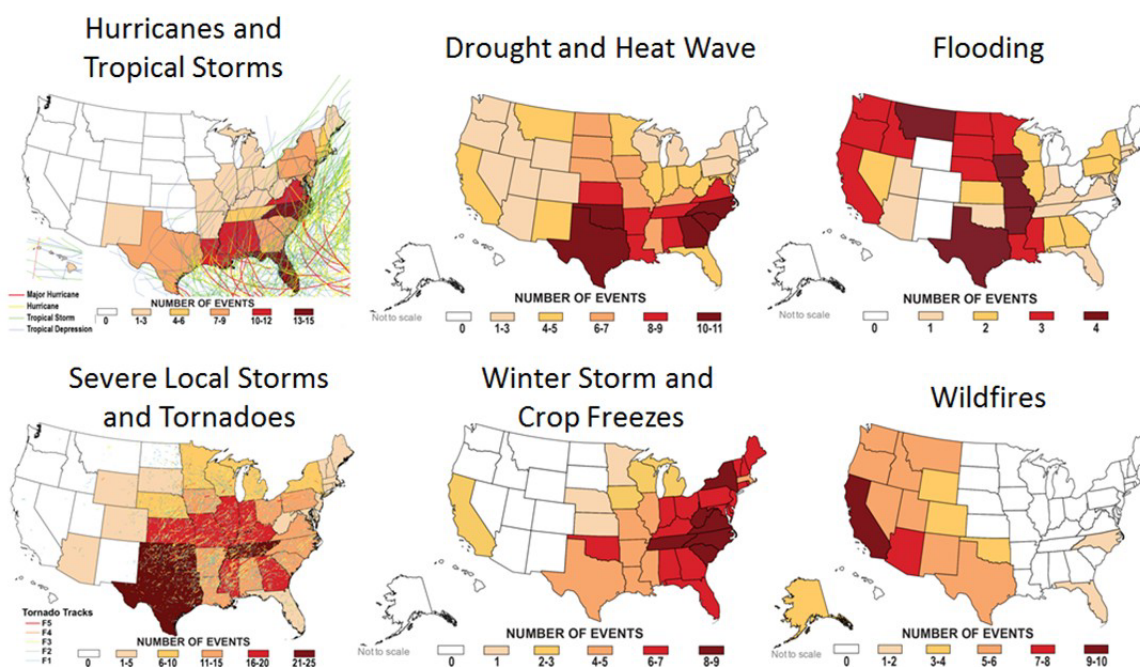


Figure 1. Number of billion-dollar events (including CPI adjustment to 2012) by event category for the period 1980 – 2011. Costs of wide-area events are apportioned across states, and may not amount to \$1B of damage in each affected state. The 'Severe Local Storms and Tornadoes' map reflects billion-dollar events for combined tornado, hail and straight-line wind damage, and is overlaid by tornado-intensity tracks as one indicator of event distribution. The 'Hurricane and Tropical Storm' map is overlaid with storm tracks. Source: NOAA/NCDC.

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⁴ We would like to acknowledge the contributions of Adam Smith, Neal Lott, and James McMahon of NOAA's NCDC and the participants of the May Workshop on Billion Dollar Weather Damages, held at NCDC in Asheville.

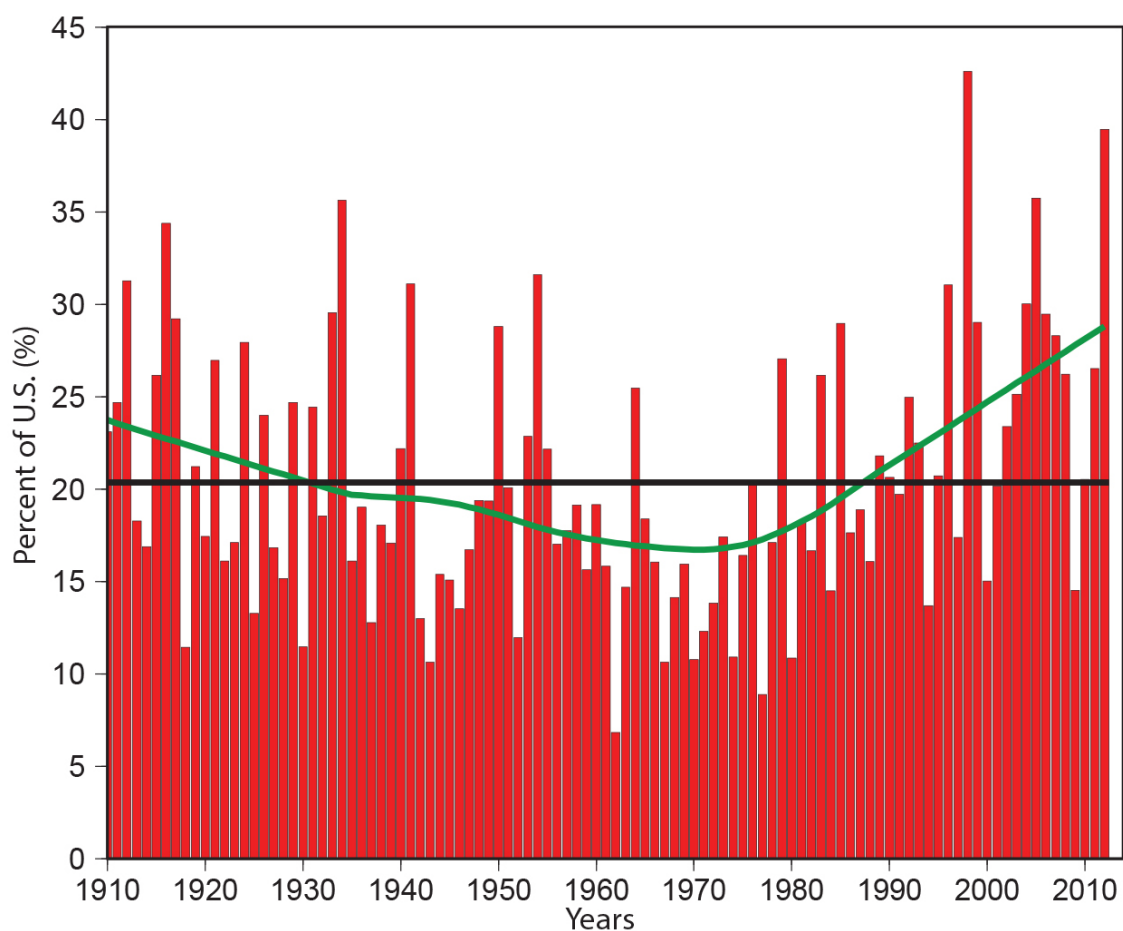


Figure 2.

Annual U.S. Climate Extremes Index 1910-2011. Red bars indicate the annual percentage of the continuous U.S. land area experiencing extreme conditions; black line is the average over entire period of record; green line shows a locally weighted linear regression method “Lowess” to indicate multidecadal changes using a smoothing span equal to 50% of the time series length. The index considers extremes in maximum and minimum temperature, soil moisture excess and deficits, extremes in 1-day precipitation; extremes in days with or without precipitation; and landfalling tropical storm and hurricane wind speed and duration. Based on change pointⁱ and non-parametric tests of statistical significanceⁱⁱ, there is a significant (0.01) positive trend in the Index value since the late 1960’s, but no overall significant trend since 1910, nor any significant decreasing trend from 1910 to the late 1960’s. Several important extremes are not yet reflected in the index, including tornados and severe thunderstorm outbreaks, ice storms, and blizzards/snowstorms.ⁱⁱⁱ

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